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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/052,999	11/02/2001	Partha P. Tirumalai	SUN-P7133-RA	1267
22835	7590	09/23/2004	EXAMINER	
PARK, VAUGHAN & FLEMING LLP 508 SECOND STREET SUITE 201 DAVIS, CA 95616			FOWLKES, ANDRE R	
			ART UNIT	PAPER NUMBER
			2122	

DATE MAILED: 09/23/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 10/052,999	Applicant(s) TIRUMALAI ET AL.	
	Examiner Andre R. Fowlkes	Art Unit 2122	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 22 September 2003.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-17 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) _____ is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☒ Claim(s) 18-45 are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 11/2/01 is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date <u>9/22/03</u> . | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

1. Claims 1-17 are pending.

Election/Restrictions

2. Restriction to one of the following inventions is required under 35 U.S.C. 121:
 - I. Claims 1-17, drawn to a method, computer-readable medium and apparatus for calculating stride values of data references in order to determine an optimal strategy for performing anticipatory prefetching of data references , classified in class 717, subclass 160.
 - II. Claims 18-31, drawn to a method, computer-readable medium and apparatus for performing anticipatory prefetching by inserting multiple prefetch instructions for a given data reference, classified in class 717, subclass 160.
 - III. Claims 32-45, drawn to a method, computer-readable medium and apparatus for performing anticipatory prefetching by using the location in code where a prefetch address for a given prefetch instruction is calculated in combination with the location of the corresponding data reference operation to determine the optimal placement for the prefetch instruction, classified in class 717, subclass 160.
3. The inventions are distinct, each from the other because of the following reasons:

Art Unit: 2122

4. Inventions I, II and III are related as combination and subcombination. Inventions in this relationship are distinct if it can be shown that (1) the combination as claimed does not require the particulars of the subcombination as claimed for patentability, and (2) that the subcombination has utility by itself or in other combinations (MPEP § 806.05(c)).

5. In the instant case, invention I, as claimed does not require the particulars of invention II or III as claimed because an optimal strategy for performing anticipatory prefetching of data references is determined without performing all of the techniques claimed in inventions II or III. Invention II, as claimed does not require the particulars of invention I or III as claimed because anticipatory prefetching by inserting multiple prefetch instructions for a given data reference is accomplished, without performing all of the techniques claimed in inventions I or III. Invention III, as claimed does not require the particulars of invention I or II as claimed because anticipatory prefetching by using the location in code where a prefetch address for a given prefetch instruction is calculated in combination with the location of the corresponding data reference operation to determine the optimal placement for the prefetch instruction is performed without performing all of the techniques claimed in inventions I or II.

6. Invention I has separate utility such as determining a strategy for performing anticipatory prefetching of data references that is optimal, in terms of stride values of data references. Invention II has separate utility such as performing anticipatory

prefetching by inserting multiple prefetch instructions for a given data reference in a way that increases the odds that a prefetch instruction will be executed, as opposed to dropped by the computer system. Invention III has separate utility such as performing anticipatory prefetching of data that is optimal, in terms of the location in code where a prefetch address for a given prefetch instruction is calculated in combination with the location of the corresponding data reference operation.

7. During a telephone conversation with A. Richard Park of Park, Vaughan & Fleming, LLP on 9/9/04, a provisional election was made without traverse to prosecute the invention of Group I, consisting of claims 1-17. Affirmation of this election must be made by applicant in reply to this Office action. Claims 18-45 are withdrawn from further consideration by the examiner, under 37 CFR 1.142(b), as being drawn to a non-elected invention.

8. Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a request under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(i).

Claim Rejections - 35 USC § 102

9. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

10. ~~Claims 1-17 are rejected under 35 U.S.C. 102(b) as being anticipated by~~
Santhanam, U.S. Patent No. 5,704,053.

As per claim 1, Santhanam discloses **a method for generating code to perform anticipatory prefetching for data references**, (col. 3:47-49, "The current invention provides a new compiler for such a processor that facilitates efficient insertion of explicit data prefetch instructions into loops within application programs"),
comprising:

- **receiving code to be executed on a computer system; analyzing the code to identify data references to be prefetched** (col. 3:50-51, "The compiler uses ... analysis (techniques) to determine data prefetching requirements"),

- **inserting prefetch instructions into the code in advance of the identified data references** (col. 3:51-53, "Analysis and explicit data cache prefetch instruction insertion are performed by the compiler"),

- **wherein inserting the prefetch instructions involves:**

- attempting to calculate a stride value for a given data reference

within a loop (col. 6:3-5, "The compiler can predict (by attempting to calculate a stride value) which data (reference) is needed in advance for loops that access array elements in a regular fashion"),

- if the stride value cannot be calculated, setting the stride value to a default stride value (col. 14:48-49, "(if the stride cant be calculated), then substitute some fixed constant, C"),

- inserting a prefetch instruction to prefetch the given data reference for a subsequent loop iteration based on the stride value (col. 6:5-8, "The compiler can then insert prefetch instructions into loops such that array elements that are likely to be needed in future loop iterations are retrieved from memory ahead of time").

As per claim 2, the rejection of claim 1 is incorporated and further, Santhanam discloses **allowing a system user to specify the default stride value** (col. 13:39, "Estimating the average loop iteration latency").

As per claim 3, the rejection of claim 1 is incorporated and further, Santhanam discloses that **calculating the stride value involves:**

- identifying an induction variable for the stride value (col. 11:23, "Identify simple basic loop induction variables"),

- **identifying a stride function for the stride value and calculating the stride value based upon the stride function and the induction variable** (col. 17:54-60, "a net loop increment of eight, and the element size of "A" is 8-bytes, this is a large stride equivalence class, assuming a 32-byte cache line size ($8 \times 8 \text{ bytes} = 64 \text{ bytes}$) $> 32 \text{ bytes}$ ").

As per claim 4, the rejection of claim 1 is incorporated and further, Santhanam discloses that **inserting the prefetch instruction based on the stride value involves:**

- **calculating a prefetch cover distance by dividing a cache line size by the stride value** (col. 15:64-67, "When the memory stride is \leq cache line size, B(i) is considered to be in the same cluster as B(i+1), and therefore omitted for prefetch consideration (i.e. the prefetch cover distance is calculated based on the cache line size and stride value)", and col. 17:54-66, "(Because the loop has) a net loop increment of eight, and the element size of "A" is 8-bytes, this is a large stride equivalence class, assuming a 32-byte cache line size ($8 \times 8 \text{ bytes} = 64 \text{ bytes}$) $> 32 \text{ bytes}$. All eight references to "A" are placed into the same cluster because they exhibit group spatial locality, and no group temporal locality. The cluster leader is the reference to A[i+7], and the span of the cluster is 64-bytes (i.e. $\&A[i+7] - \&A[i]$). If the prefetch memory distance was computed earlier to be 128-bytes, i.e. corresponding to a prefetch iteration distance of two, it is only necessary to insert three prefetch instructions to account for the entire span of this 8-member cluster.") ,

- **calculating a prefetch ahead distance as a function of a prefetch latency, the prefetch cover distance and an execution time of a loop** (col. 7:11-18, "The memory address is determined based on the number of loop iterations in advance (i.e. the prefetch iteration distance or PFID) that data items need to be prefetched to fully hide the time required to service potential data cache misses. The PFID is determined taking into account the nature of the loop body instructions (i.e. execution time of the loop and the prefetch cover distance) and characteristics of the target processor and memory system (i.e. the prefetch latency and prefetch cover distance)"),

- **calculating a prefetch address by multiplying the stride value by the prefetch cover distance and the prefetch ahead distance and adding the result to an address accessed by the given data reference** (col. 7:11-18, "The memory address is determined based on the number of loop iterations in advance (i.e. the prefetch iteration distance or PFID) that data items need to be prefetched to fully hide the time required to service potential data cache misses. The PFID is determined taking into account the nature of the loop body instructions and characteristics of the target processor and memory system.").

As per claim 5, the rejection of claim 1 is incorporated and further, Santhanam discloses that analyzing the code involves:

- **identifying loop bodies within the code; identifying data references to be prefetched from within the loop bodies** (col. 8:30-35, "One important feature of the invention identifies loops and access patterns to allow a determination of how many

cycles are devoted to loop iterations, and therefore allows insertion of the prefetch instruction to a location of an array that is sufficiently far in advance to make sure that the miss time is minimized.”).

As per claim 6, the rejection of claim 5 is incorporated and further, Santhanam discloses that analyzing the code to identify data references to be prefetched involves **examining a pattern of data references over multiple loop iterations** (col. 14:6-10, “Now, it is also necessary to address the issue of loops that have internal branches. The minimum loop iteration latency for such loops is estimated by using previously collected execution profile information, which indicates the execution count for each basic block in the loop body.”).

As per claim 7, the rejection of claim 1 is incorporated and further, Santhanam discloses that analyzing the code involves **analyzing the code within a compiler** (col. 3:47-49, “The current invention provides a new compiler for such a processor that facilitates efficient insertion of explicit data prefetch instructions into loops within application programs”).

As per claims 8-12, this is a computer readable medium/product version of the claimed method discussed above, in claims 1-7, wherein all claimed limitations have also been addressed and/or cited as set forth above. For example, see Santhanam’s “new compiler” (col. 3:47-49).

As per claims 13-17, this is an apparatus version of the claimed method discussed above, in claims 1-7, wherein all claimed limitations have also been addressed and/or cited as set forth above. For example, see Santhanam Fig. 1 computer architecture, item 10 and associated text.

Conclusion


11. After October 25, 2004, the examiner can be reached at new telephone number (571) 272-3697, and the examiner's supervisor, Tuan Q. Dam can be reached on (571) 272-3695.

12. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Andre R. Fowlkes whose telephone number is (703)305-8889. The examiner can normally be reached on Monday - Friday, 8:00am-4:30pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tuan Q. Dam can be reached on (703)305-4552. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

ARF



TUAN DAM
SUPERVISORY PATENT EXAMINER